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CRETACEOUS AND TERTIARY MICROPLANKTON FROM SOUTH-EASTERN AUSTRALIA

By Isabel C. Cookson
Botany Department, University of Melbourne

Abstract

One new genus and 4 new species of microplankton are described from Upper Eocene sediments in Victoria. A new Upper Cretaceous species is described and 2 Victorian Upper Cretaceous records included.

Introduction

The present paper is mainly concerned with a few of the many types of microplankton that occur in the sequence of Upper Eocene deposits situated at Brown's Ck in the Aire District, SW. Victoria (Carter 1958). The samples studied are representative of the Brown's Creek Clays (Carter loc. cit.), a carbonaceous clay, Greensand, a calcareous clay 15 ft above the Greensand, and a gritty clay 40-50 ft above the Greensand.

In addition, the occurrence is recorded of 3 microplankton types in Victorian Upper Cretaceous deposits, one of which had been known previously only from the Northern Hemisphere (Wetzel 1961, Gorka 1963, Manum & Cookson 1954). All 3 came from samples made available by Frome Broken Hill Co. from bores sunk in SW. Victoria. One of the Cretaceous types also occurs in a core-sample at 327 ft from SANTOS Oodnadatta Bore, South Australia provided by Dr R. C. Sprigg of Adelaide.

The holotypes and hypotypes are in the palaeontological collection of the National Museum of Victoria. Numbers prefaced by the letter P are registered numbers in that collection.

Systematic Descriptions

Class Dinophyceae

Family Hystrichosphaeridiaceae Evitt

Genus **Diphyes** n.gen.

Description: Shell composed of two parts, more or less unequal in size. The anterior part circular in outline with or without appendages. Archeopyle apical. The posterior part roughly bell-shaped to spherical with a small circular antapical opening and without typical appendages.

Type Species: *Diphyes colligerum* (Deflandre & Cookson)

Comment: This genus ,while having a hystrichosphaeridoid appearance, differs from other genera in the Hystrichosphaeridiaceae in its constantly bipartite form. Whether or not these two parts communicate cannot be proved beyond doubt. In a few specimens mounted in an anteroposterior position it has been possible to focus from one cavity to the other without any apparent obstruction to the view (Pl. 9, fig. 5, 6) so that if a dividing wall does exist, as was stated in the original description of

the type species (Deflandre & Cookson 1955), it must be a very thin one. Sections are the only solution to this morphological problem.

Diphyes colligerum (Deflandre & Cookson)

(Pl. 9, fig. 1-12; hypotypes fig. 1, 2, P23029-23030)

non *Hystrichosphaeridium* sp. *c* Cookson 1953, Pl. 2, fig. 29, 30.
Hystrichosphaeridium colligerum Deflandre & Cookson 1955, p. 178. Pl. 7, fig. 3. Holotype P16301.
Baltisphaeridium colligerum (Deflandre & Cookson) Downie & Sarjeant 1963, p. 91.

Age and Occurrence: Probably Senonian: Frome Broken Hill Co. Eumeralla No. 1 Bore, SW. Vict. between 3050 and 3060 ft. Eocene: type locality Princetown member of Dilwyn Clay, Cape Ronald, SW. Vict. 5 ft above beach level; Rottnest Bore, W.A. between 1480 and 1541 ft (Cookson & Eisenack 1961); new locality Upper Eocene Brown's Ck, SW. Vict. Greensand and deposit 15 ft above the Greensand.

Emended Description: Anterior portion of shell almost spherical, dorsoventral, with numerous broadly-based, stiff or flexuous, usually unbranched tubular appendages of varying lengths and widths that narrow towards small bluntly-pointed, capitate or somewhat funnel-shaped apices. On one surface, taken as ventral, some of the appendages are arranged in two short longitudinal rows one on either side of the mid-line (Pl. 9, fig. 1, 3); on the dorsal surface they are evenly distributed (Pl. 9, fig. 2, 4); an archeopyle occupies a large part of the apex (Pl. 9, fig. 5). The appendages are hollow at and near their bases and, contrary to the statement of Deflandre & Cookson (1955), their cavities appear to communicate with that of the shell (Pl. 9, fig. 10). However, it is practically impossible to prove this point, as well as to trace the cavity along the whole length of the longer appendages owing to the narrowness of their distal portions and the relative thickness of their walls. The wall of the anterior portion of the shell, *c.* 1·5 μ thick, is two-layered. The outer layer is densely granular in surface view the granules appearing as minute rods in optical section under oil immersion; similar rods are frequently evident on the walls of the appendages.

Posterior portion of the shell usually smaller and thinner-walled than the anterior portion, roughly bell-shaped with straight or convex sides and, in well-preserved specimens, a centrally-placed, cone-like projection with a small circular opening (Pl. 9, fig. 12). The surface is devoid of appendages, apart from one or two circles of small, knob or spine-like thickenings in the vicinity of the antapical opening (Pl. 9, fig. 7, 8, 11). The wall, *c.* 1 μ thick, is smooth in optical section, finely granular in surface view, the granules being arranged in more or less clearly defined longitudinal rows (Pl. 9, fig. 1).

Dimensions: Hypotypes—(Pl. 9, fig. 2) overall length of shell 55 μ, width of anterior part 31 μ, width of posterior part *c.* 26 μ; (Pl. 9, fig. 3) overall length of shell 57μ ,width of anterior part *c.* 33 μ, width of posterior part 26 μ. Range—overall length 36-57 μ; width, anterior part 29-36 μ, posterior part 13-26 μ; appendages 5-21 μ long.

Comment: The recovery of a single specimen of *D. colligerum* (Pl. 9, fig. 4) from cuttings taken from Frome Broken Hill Co. Eumeralla No. 1 Bore between 3050 and 3060 ft requires special consideration. The deposit at this level, in containing several types of Dinoflagellates, e.g. *Deflandrea thomasi* Cookson & Eisenack and *D. belfastensis* Cookson & Eisenack (1961), which occur in other Upper

Cretaceous deposits in SW. Victoria, is undoubtedly of Upper Cretaceous age, Senonian or younger. This occurrence suggests that the time-range of *D. colligerum* may have been from high in the Upper Cretaceous to Upper Eocene. Since the residue in which this specimen occurred came from cuttings, additional examples from Upper Cretaceous deposits will be needed to establish such a range.

The reference of the Tertiary form *Hystrichophaeridium* sp. *c* Cookson 1953 to *Hystrichosphaeridium colligerum* by Deflandre & Cookson is herein disallowed following a re-examination of the figured specimen. This specimen shows no sign of the bipartite shell typical of the new genus *Diphyes* and its type species *D. colligerum*. Occasional specimens of *D. colligerum* in which the posterior part is exceptionally narrow (*c.* 13 μ) and straight-sided, bear a superficial resemblance to some examples of the genus *Coronifera* Cookson & Eisenack 1958.

Diphyes nudum n. sp.

(Pl. 10, fig. 1-4; holotype fig. 1, P23031; paratype fig. 4, P23032)

Age and Occurrence: Upper Eocene: Brown's Creek Greensand, SW. Victoria.

Description: Both parts of the shell without appendages. Anterior portion slightly larger than posterior portion, almost spherical with a large apical archeopyle. Wall *c.* 2 μ thick, smooth in profile, faintly dotted to finely granular in surface view.

Posterior portion slightly smaller than the anterior portion with convex sides and a slight apical prominence with a small opening; wall *c.* 1 μ thick, smooth in profile, faintly dotted or finely granular in surface view the granules when developed being arranged in regular longitudinal rows as in *D. colligerum* (Pl. 10, fig. 3, 4).

Dimensions: Holotype—overall length 55 μ, anterior part 35 μ wide, posterior part 32 μ wide. Range—overall length 47-65 μ ,width of anterior part 31-42 μ, width of posterior part 26-36 μ.

Comment: Although only 12 specimens of *D. nudum* have been found, the complete absence of appendages from the anterior portion of the shell seems sufficiently constant to justify specific distinction.

Genus **Hystrichosphaeridium** Deflandre

Hystrichosphaeridium ellipticum n. sp.

(Pl. 11, fig. 1-3a; holotype fig. 1, P23033; paratype fig. 2, P23095)

Age and Occurrence: Upper Eocene: Brown's Ck Greensand, calcareous clay 15 ft above Greensand.

Description: Shell elliptical in outline, untabulated, thin-walled with about 30-45 hollow appendages of varying lengths and widths which tend to be more numerous in the vicinity of apex and antapex (Pl. 11, fig. 2, 3). Archeopyle apical with a truncate edge. Appendages simple or branched, unequal in size, narrowing distally from base to broaden again apically; apices funnel-shaped, varying considerably in both width and depth, rims fringed with fine, branched processes the ultimate branchlets frequently visible only under oil immersion (Pl. 11, fig. 3a); cavities of appendages traceable to the main processes fringing the rims (Pl. 11, fig. 3a). Shell-membrane *c.* 0·5 μ or less thick, two-layered, outer layer smooth in op-

tical section, finely and closely granular in surface view, sometimes more conspicuously so near the bases of the appendages especially at the antapex.

Dimensions: Holotype—overall length *c.* 187 μ, overall width *c.* 109 μ; shell 101 × 52 μ. Range—three open shells, length 83 μ, width 47-52 μ; appendages 21-39 μ long.

Comment: A close affinity is evident between *H. ellipticum* and *H. paradoxum* Brosius 1963 from certain German mid-Oligocene deposits. Both have elongate-oval shells and funnel-shaped appendages of varying lengths and widths. However, judging by the illustrations of Brosius, the number of appendages in *H. paradoxum* (unfortunately not specified in the text) is considerably lower than that in *H. ellipticum*. Moreover, the long 'flagelliform' processes bordering the rims of the appendages (Brosius loc. cit. Abb 2) are shown as unbranched in contrast to the secondary and tertiary branchlets of *H. ellipticum*. In addition, the dimensions of open shells of *H. ellipticum* considerably exceed those given for *H. paradoxum*.

Family Areoligeraceae Evitt

Genus **Cyclonephelium** Deflandre & Cookson emended Cookson & Eisenack 1962

Cyclonephelium retiintextum n. sp.

(Pl. 11, fig. 4; holotype, P23094)

Age and Occurrence: Upper Cretaceous: Senonian or younger, Frome Broken Hill Co. Eumeralla No. 1 Bore, cuttings taken between 3090 and 3100 ft, and 3110 and 3120 ft.

Description: Shell oval with a small, median, blunt apical projection; archeopyle apical. Ornament in the form of an open-meshed network formed by the distal anastomosis of simple or more commonly slender branched processes of variable widths (*c.* 0·5μ-5μ) which arise well within the margin of the shell (*c.* 15-21μ); sometimes the bases of adjacent processes are connected by straight or curved strands. The distal branches delimiting the meshes are occasionally somewhat flattened and slightly perforated. The unornamented central portions of both dorsal and ventral surfaces are relatively small (*c.* 42 μ wide in the holotype). The shell membrane is two-layered, thin (*c.* 1 μ) and finely granular.

Dimensions: Holotype—overall length 177μ, overall width 117μ, shell 94 × 78μ, appendages 20-30 μ long.

Comment: Only 2 specimens have been found. The unfigured paratype (P23097) is open apically but otherwise agrees with the holotype.

Of the described species of *Cyclonephelium* the one to which *C. retiintextum* approaches at all closely is *C. reticulosum* Gerlach (1961) from an Upper Oligocene deposit in NW. Germany. In this species, it is evident from the description and figure that the processes forming the network are situated close to the margin of the shell and that, in consequence, the greater part of both dorsal and ventral surfaces are unornamented. This arrangement clearly contrasts with the more central position of the network and the consequent smaller size of the unornamented surfaces of *C. retiintextum*. In addition, the distal finely reticulate bands associated with the reticulum of *C. reticulosum* have not been observed in *C. retiintextum*.

Family Uncertain

Genus **Horologinella** Cookson & Eisenack

Horologinella incurvata Cookson & Eisenack

(Pl. 10, fig. 13)

Horologinella incurvata Cookson & Eisenack 1962, p. 272, Pl. 37, fig. 5.

COMMENT: A few specimens identical with the type and other specimens from Eocene deposits in the Rottnest Is. Bore, Western Australia between 1285 and 1385 ft, and 1480 and 1541 ft have been observed in preparations of the Greensand and clay 15 ft above Greensand from Brown's Ck, SW. Victoria. An opening has not been evident.

Horologinella? spinosa n. sp.

(Pl. 10, fig. 10-12; Pl. 11, fig. 10; holotype fig. 11, P23036; paratypes fig. 12, P23037, Pl. 11, fig. 10, P23096)

OCCURRENCE: Upper Eocene: Brown's Ck, SW. Victoria. Carbonaceous clay, Greensand, calcareous clay 15 ft above Greensand, and gritty clay 40-50 ft above Greensand.

DESCRIPTION: Cyst without fields, with deeply concave sides and straight to slightly concave ends (cf. *H. incurvata* Pl. 11, fig. 13). Wall *c.* 0·5-1μ, thick mainly smooth, except at the distal rounded ends of the 4 arms where it is ornamented with small, solid, spine-like projections. One of the arms at the 'anterior' end is slightly longer than the other 3 and sometimes narrows slightly towards the apex. In 2 examples (cf. Pl. 11, fig. 10) the apex of the longer arm is open, apparently as the result of a natural transverse break.

DIMENSIONS: Holotype—*c.* 42 μ long, 39 μ broad. Range—*c.* 23-42 μ long, *c.* 23-39μ broad.

COMMENT: This form is doubtfully referred to *Horologinella* on account of its resemblance to the capsule of *Halophoridia xena* Cookson & Eisenack 1962, especially as regards the greater prominence and narrower shape of one of the 'anterior' arms. However, in *H. xena* the capsule is enclosed in a hyaline membrane whereas, in the 10 specimens of *Horologinella? spinosa* seen, no trace of such a membrane has been present.

H.? spinosa differs from the cysts of the described species of *Horologinella* Cookson & Eisenack 1962 and the capsules of *Halophoridia xena* in the development of spines at and adjacent to the apices of the 4 arms. In 3 specimens (Pl. 10, fig. 10) minute dot-like thickenings are scattered over the general surface; in the holotype (Pl. 10, fig. 11) 2 groups of dots are present, one at each end of the 'waist'-like region.

INCERTAE SEDIS

ACRITARCHA Evitt

Subgroup ACANTHOMORPHITAE Downie, Evitt, & Sarjeant

Genus **Baltisphaeridium** Eisenack

Baltisphaeridium nanum n. sp.

(Pl. 10, fig. 5-8; holotype fig. 5, P23034; paratype fig. 9, P23035)

AGE AND OCCURRENCE: Upper Eocene: Brown's Ck, SW. Victoria carbonaceous clay, Greensand, calcareous clay 15 ft above Greensand, and gritty clay 40-50 ft above Greensand.

DESCRIPTION: Shell small, usually circular in outline, densely covered with short, unbranched, hair-like appendages with slightly broadened bases, the lengths of which are about ¼-⅓th of the diameter of the shell. Opening *c.* 2 μ, roundish in outline.

DIMENSIONS: Holotype—overall diameter 44 μ, diameter of shell 33 μ; appendages *c.* 5 μ. Range—overall diameter *c.* 36-55 μ, diameter of shell *c.* 23-34 μ; appendages *c.* 5-13 μ long.

COMMENT: *B. nanum* is a regular, though not frequent component of the microplankton assemblages contained in the 4 deposits from Brown's Ck mentioned above. It seems to be distinguishable from all the well-illustrated species of *Baltisphaeridium* in the combination of small shell-size and large number of short hair-like appendages. The species to which *B. nanum* is most closely similar is *B. whitei* (Deflandre & Courteville 1939)originally described from French Senonian flints but the shells of this form are consistently larger, 56-60 μ, and the 'filaments' longer, up to about 28 μ, than those of *B. nanum*. In two examples of the latter, the shell seems to narrow slightly and the appendages to be fewer at this point (Pl. 10, fig. 7, 8), an appearance that could be related to the small opening occasionally seen in surface views (Pl. 10, fig. 9).

Baltisphaeridium striatoconus (Deflandre and Cookson)

(Pl. 11, fig. 9)

Hystrichosphaeridium striatoconus Deflandre & Cookson 1955, p. 275.
Hystrichosphaeridium striatoconus Deflandre & Cookson, Cookson & Eisenack 1960, p.8.
Baltisphaeridium striatoconus (Deflandre & Cookson) Downie & Sarjeant 1963, p. 91.

COMMENT: Until recently, when Evans (1961) reported the occurrence of *B. striatoconus* in the Port Campbell No. 1 Bore in SW. Victoria between 5700 and 5705 ft, this distinctive species had been known only from Western Australia. Evans estimated the age at this level as Cenomanian on the basis of the occurrence of *Deflandrea acuminata* Cookson & Eisenack (1958) originally described from the upper part of the Gearle siltstone from West Australian Petroleum Co. Rough Range No. 5 Bore at 1570 ft and No. 8 Bore between 1530 and 1548 ft, the age of which had been regarded as Cenomanian to Turonian.

A second Victorian occurrence of *B. striatoconus* can now be reported namely in deposits intersected by the Port Campbell No. 2 Bore between 7403 and 7408 ft, and 7440 and 7750 ft, the age of which is suggested by Taylor (1964) as Turonian. In these deposits, as well as in the Port Campbell No. 1 Bore, *B. striatoconus* is associated with the pollen tetrad *Amosopollis cruciformis* Cookson & Balme 1962, p. 99.

The association of these two forms in Victoria is of stratigraphical interest. As far as is known both forms had restricted time-ranges. In Western Australia the time-range of B. *striatoconus* appears to have been from Turonian to Santonian. A Turonian age was indicated by its occurrence in the Upper Gearle Siltstone, Rough Range South Bore between 2500 and 2514 ft, the age estimated by Dr M. F. Glaessner (unpublished report to WAPET). A Santonian age has been suggested by Dr H. S. Edgell (pers. com.) for the Molecap Greensand from which *B. striatoconus* was first recovered. The time-range given by Cookson & Balme (1962) for the Western Australian occurrence of *Amosopollis cruciformis* is Albian to Cenomanian.

From the present evidence it would appear that the ranges of *A. cruciformis* and *B. striatoconus* are extended and overlap. This overlap probably represents Upper Cenomanian to Lower Turonian times.

A similar association of *B. striatoconus* and *A. cruciformis* occurs in the Balcatta No. 1 Bore, Perth Metropolitan area, Western Australia between 180 and 210 ft. In the deposit intersected between 220 and 277 ft in this bore, *A. cruciformis* occurs together with such forms as *Actinotheca aphroditae* Cookson & Eisenack 1960 (Turonian), *Gillinia hymenophora* Cookson & Eisenack 1960 (Upper Turonian to Senonian), *Cyclodictyon paradoxus* Cookson & Eisenack 1960 (Cenomanian to Lower Turonian), and *Deflandrea* cf. *acuminata* Cookson & Eisenack (1958) (Cenomanian to Lower Turonian).

Class CHLOROPHYCEAE

(Order PROTOCOCALES?)

Family Uncertain

Palambages O. Wetzel

Palambages Form A Manum & Cookson

(Pl. 11, fig. 5-8; 8, P23038; 5, P23039; 7, P23093)

Palambages Form A Manum & Cookson 1964.

AGE AND OCCURRENCE: Albian: SANTOS Oodnadatta No. 1 Bore, South Australia at 327 ft. Lower Upper Cretaceous: Frome Broken Hill Co. Flaxman's No. 1 Bore W. of Port Campbell between 6375 and 6391 ft, 6663 ft; Port Campbell No. 2 Bore between 7403 and 7408 ft; Port Campbell No. 3 Bore between 4610 and 4620 ft, and 4650 and 4670 ft. Upper Cretaceous, ?Senonian or younger: Eumeralla No. 1 Bore NW. Port Fairy, Victoria, cuttings taken between 3020 and 3030 ft, 3080 and 3090 ft; 3100 and 3110 ft.

COMMENT: Clusters of cells suggestive of green algal colonies were first recorded from Baltic Senonian and Danian flints by O. Wetzel (1934) under the provisional name *Morulosae*. In 1961, Wetzel established the genus *Palambages* for these colonies with the type species *P. morulosa*. Comparable colonies and a new species have since been recorded from Maestrichtien deposits in Poland (H. Górka 1963) and 3 forms, *Palambages* Forms A, B, and C, deserибed by Manum & Cookson (1964) from lower Upper Cretaceous deposits in Graham and Ellef Ringnes Islands, Arctic Canada.

The distribution of *Palambages* can now be extended to the Southern Hemisphere as the result of the recovery of colonies referable to it from the SE. Australian Albian and Upper Cretaceous deposits mentioned above. In these colonies the number of cells per individual has varied considerably and usually exceeded that given by Wetzel for *P. morulosa*. In this and other respects the Australian specimens agree most closely with *P.* Form A Manum & Cookson 1964, with which it seems best to associate them until such time as more is known about the genus as a whole and the characters upon which individual species can reliably be based.

The cells of the Australian examples are *c.* 12-21μ in diameter and the number of cells per colony seems to range between 12 and 60. The walls of the cells are smooth or finely granular in profile, finely dotted in surface view.

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Explanation of Plates

Magnifications × *c.* 670 unless otherwise stated.

Plate 9

Fig. 1, 2, 3, 5-12—*Diphyes colligerum* (Deflandre & Cookson) Brown's Creek Greensand. 1, ventral surface × *c.* 1,000; 2, dorsal view; 3, a specimen with short, stiff appendages in ventral view; 5-7, three views of the same specimen; 5, surface view of apex; 6, deeper view showing inner surface of antapex and the small wall-thickenings around it; 7, dorsal view × *c.* 480; 8, 9, posterior portion of a shell at two foci showing circle of small prominences; 10, portion of wall of anterior part of shell showing base of an appendage in surface view and a complete appendage the cavity of which is visible for

about half its length × *c.* 1500; 11, surface view of an antapex showing circle of prominences and position of future opening; 12, antapex showing position of opening.

Fig. 4—*D. colligerum,* from an Upper Cretaceous deposit between 3050 and 3060 ft in Eumeralla Bore, SW. Victoria.

PLATE 10

Fig. 1-4—*Diplyes nudum* n.sp. Brown's Ck Greensand.

Fig. 5-9—*Baltisphaeridium nanum* Brown's Ck; 5-6, carbonaceous clay below Greensand × *c.* 1500; 7-9, Greensand; 9, showing opening.

Fig. 10-12—*Hologinella? spinosa* n.sp. Brown's Ck. 10, Greensand showing minute dots over the general surface; 11-12, gritty clay 40-50 ft above Greensand; 11 × *c.* 1100.

Fig. 13—*Horologinella incurvata* Cookson & Eisenack. Brown's Ck Greensand.

PLATE 11

Fig. 1-3a—*Hystrichosphaeridium ellipticum* n.sp. Brown's Ck Greensand. 3a, a primary process showing a central cavity and secondary and tertiary branches × *c.* 1500.

Fig. 4—*Cyclonephelium retiintextum* n.sp. Eumeralla No. 1 Bore between 3090 and 3100 ft × *c.* 480.

Fig. 5-8—*Palambages* Form A Manum & Cookson. 5, 8, Eumeralla No. 1 Bore; 5, at 3080 ft *c.* 16-celled colony × 1150; 8, between 3050 and 3060 ft *c.* 12-celled colony; 6, 7, Flaxmans No. 1 Bore between 6379 and 6391 ft. 7, *c.* 60-celled colony.

Fig. 9—*Baltisphaeridium striatoconus* (Deflandre & Cookson) Port Campbell No. 2 Bore between 7603 and 7608 ft.

Fig. 10—*Horologinella? spinosa* n.sp. Brown's Ck, calcareous clay 15 ft above Greensand.